NURBS-Enhanced Finite Volume Method (NEFVM))

Ruben Sevilla, Oubay Hassan and Ken Morgan

Civil and Computational Engineering Centre
Swansea University
SA2 8PP, Wales, UK
e-mail: r.sevilla@swansea.ac.uk, o.hassan@swansea.ac.uk, k.morgan@swansea.ac.uk

ABSTRACT

The relevance of a proper description of curved boundaries in computational fluid dynamics applications is receiving increasing attention [1]. In particular, several alternatives have been recently proposed to work with the exact (CAD) geometric model, see for instance the *isogeometric analysis* [2] or the *NURBS-Enhanced Finite Element Method (NEFEM)* [3]. NEFEM provides a natural way towards the integration of CAD into an existing finite element code due to the use of the standard NURBS boundary representation of the computational domain. The efficiency and performance of this methodology encourages the extension of this rationale to other numerical techniques.

This work presents the *NURBS-Enhanced Finite Volume Method* (NEFVM). The exact geometry of the computational domain is considered by means of its standard boundary representation using *Non-Uniform Rational B-Splines (NURBS)*. For elements not intersecting curved boundaries the classical finite volume approximation is considered, and only for those elements whose geometry is affected by curved boundaries a specific strategy is considered. Therefore, the overhead introduced by the exact boundary representation is restricted only to elements in contact with curved boundaries. In fact, the overhead introduced in a finite volume context is reduced to face computations affected by curved boundaries, as no element integrals are needed. Thus, NEFVM is a very attractive alternative to incorporate the exact geometric model in the numerical solution of fluid mechanics applications. In this context, it is well known than a linear approximation of the geometry is not always sufficient, even if the mesh is drastically refined near curved boundaries. For instance, in the numerical solution of the compressible Euler equations the use of a piecewise boundary description causes excessive entropy production that sometimes prevents the convergence to the correct steady-state solution, see [1,4]. The application of NEFVM to incompressible viscous flow will be presented and further compared with the standard FVM.

REFERENCES

[1] F. Bassi and S. Rebay, “High-order accurate Discontinuous Finite Element solution of the 2D Euler equations”, *J. Comput. Phys.*, v. 138, p. 251-285, 1997.

[2] T. J. R. Hughes, J. A. Cottrell and Y. Bazilevs, “Isogeometric analysis: CAD, finite elements, NURBS, exact geometry and mesh refinement”, *Comput. Methods Appl. Mech. Eng.*, v. 194, p. 4135-4195, 2005.

[3] R. Sevilla, S. Fernández-Méndez and A. Huerta , “NURBS-Enhanced Finite Element Method (NEFEM)”, *Int. J. Numer. Meth. Eng.*, v. 76, p. 56-83, 2008

[4] R. Sevilla, S. Fernández-Méndez and A. Huerta , “NURBS-Enhanced Finite Element Method (NEFEM) for Euler equations”, *Int. J. Numer. Meth. Fluids.*, v. 57, p. 1051-1069, 2008